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QUASI-STATIC COMPRESSION STRESS-STRAIN CURVES---III, 5083-H131 ALUMINUM

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E. Allen Murray, Jr.

May 1975

USA BALLISTIC RESEARCH LABORATORIES
ABERDEEN PROVING GROUND, MARYLAND

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report presents the results of quasi-static compression tests performed at 22°C on 5083-H131 aluminum rod and plate. The yield strength, Poisson's ratio and Young's modulus are reported.

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I. INTRODUCTION

The quasi-static compression tests reported herein were conducted as part of the Core Materials Program of the Solid Mechanics Branch of the Terminal Ballistics Laboratory.

This report is the third[1,2*] in a series characterizing the mechanical behavior of armor and armor penetrators. Such characterization will provide valuable information to designers of armor vehicles and armor penetrators and to those studying kinetics of armor penetration processes.

The present study presents the results of quasi-static compression tests of 5083-H131 aluminum rod and plate. The results consist of yield strength, average stress-strain curves, Poisson's ratio and Young's modulus.

II. TEST PROCEDURES

The apparatus, test procedures, and data reduction regimen used for the testing of the 5083-H131 samples have been reported previously[1]. The test specimens were right circular cylinders, 9.5mm in diameter, machined from either a one-inch diameter rod or a one-inch thick plate. The specimens cut from the plate were 24mm long and were oriented such that their long axes were perpendicular to the surface of the plate. The specimens machined from the rod were 28.6mm long and were oriented such that their long axes were parallel to the axis of the rod. Samples of both the rod and plate were sent to Frankford Arsenal for chemical analyses. The rod and plate were not from the same heat of alloy. The temperature for the tests was approximately 22°C.

III. RESULTS

Quasi-static compression tests were performed on 6 rod specimens and 6 plate specimens. The average engineering stress-strain curves from these specimens are presented in Figure 1. The vertical error bands in Figure 1 indicate the + and - standard deviation in the stress.** The tests were terminated upon failure of one of the gages. Table I shows the maximum strains attained prior to gage failure and indicates that the six tests of the plate specimens terminated at approximately the same maximum strain. Therefore, the curve shown in Figure 1 for the plate specimens is the average of six tests. The terminations of the corresponding tests of the rod specimens were

*References are listed on page 12

**Bessel's correction for small samples was applied to the calculation of the standard deviation[3].

more variable. Therefore, the number of tests used to derive the average values shown in Figure 1 for the rod specimens was dependent upon the strain, i.e. the average was based on six tests from 0.0 to 5.22 percent strain, four tests from 5.22 to 5.85 percent strain and two tests from 5.85 to 6.56 percent strain.

Figure 2 presents the longitudinal and circumferential stress-strain relationships for one specimen each of the rod and plate. Poisson's ratios calculated from the ratio of these longitudinal and circumferential strains are presented in Figure 3 up to a maximum strain of one percent. Figure 4 shows Poisson's ratio for the rod specimen up to the maximum strain attained (approximately five percent). Poisson's ratios for strains from one to five percent for all the rod and plate specimens were similar to that shown in Figure 4.

Poisson's ratio for the rod and plate is 0.32 in the elastic region, is unstable in the elastic-plastic region, and approaches 0.5 as strain increases.

TABLE I

STRAIN AT TERMINATION OF COMPRESSION TEST

SPECIMEN	ROD %	PLATE %
1	6.56	2.82
2	5.85	3.05
3	5.89	3.33
4	5.22	3.22
5	5.40	3.03
6	8.85	2.92

The average yield strength, Young's modulus, and Poisson's ratio for 5083-H131 aluminum rod and plate are presented in Table II. The values within the parentheses are the standard deviations determined from 6 tests. The yield strength is defined as that stress at which the specimens deviated 0.2 percent from proportionality of stress to strain[4].

The results of the chemical analyses of the plate and rod are shown in Table III.

TABLE II

MEASURED MATERIAL PROPERTIES
OF 5083-H131 ALUMINUM ALLOY

PROPERTY	ROD	PLATE
Average Yield Strength (megapascals)	273 (6.6)	314 (2.6)
Young's modulus (megapascals)	71.5 (1.0) $X10^3$	73.1 (0.3) $X10^3$
Poisson's ratio	0.32 (0.004)	0.32 (0.006)
Hardness (Brinell)	80	95

TABLE III

CHEMICAL ANALYSIS* OF ROD AND PLATE SAMPLES
OF 5083-H131 ALUMINUM ALLOY

Element	Weight Percent	
	ROD	PLATE
Copper	<0.1	<0.1
Silicon	0.05/0.15	0.05/0.15
Iron	0.2/0.4	0.2/0.4
Manganese	0.77 ± 0.02	0.72 ± 0.02
Zinc	<0.1	<0.1
Magnesium	4.81 ± 0.05	4.72 ± 0.05
Titanium	<0.05	<0.1
Others	<0.04	<0.04
Chromium	0.05/0.15	0.05/0.15
Nickel	<0.02	<0.02
Tin	None detected	None detected
Lead	<0.02	<0.02
Aluminum	Remainder	Remainder

*Analysis by Emission Spectroscopy - Frankford Arsenal, Materials Laboratory, Technical Support Directorate.

CONCLUSION

A series of quasi-static compression tests has been completed on samples of 5083-H131 aluminum rod and plate. The data generated from these tests have been reduced and are in a form readily applicable for users.

It is concluded from the reproducibility shown that the results presented are an accurate partial description of the elastic and plastic properties of 5083-H131 aluminum bar and plate.

ACKNOWLEDGEMENTS

The authors would like to thank Dominick DiBerardo for instrumenting the samples and performing the compression tests.

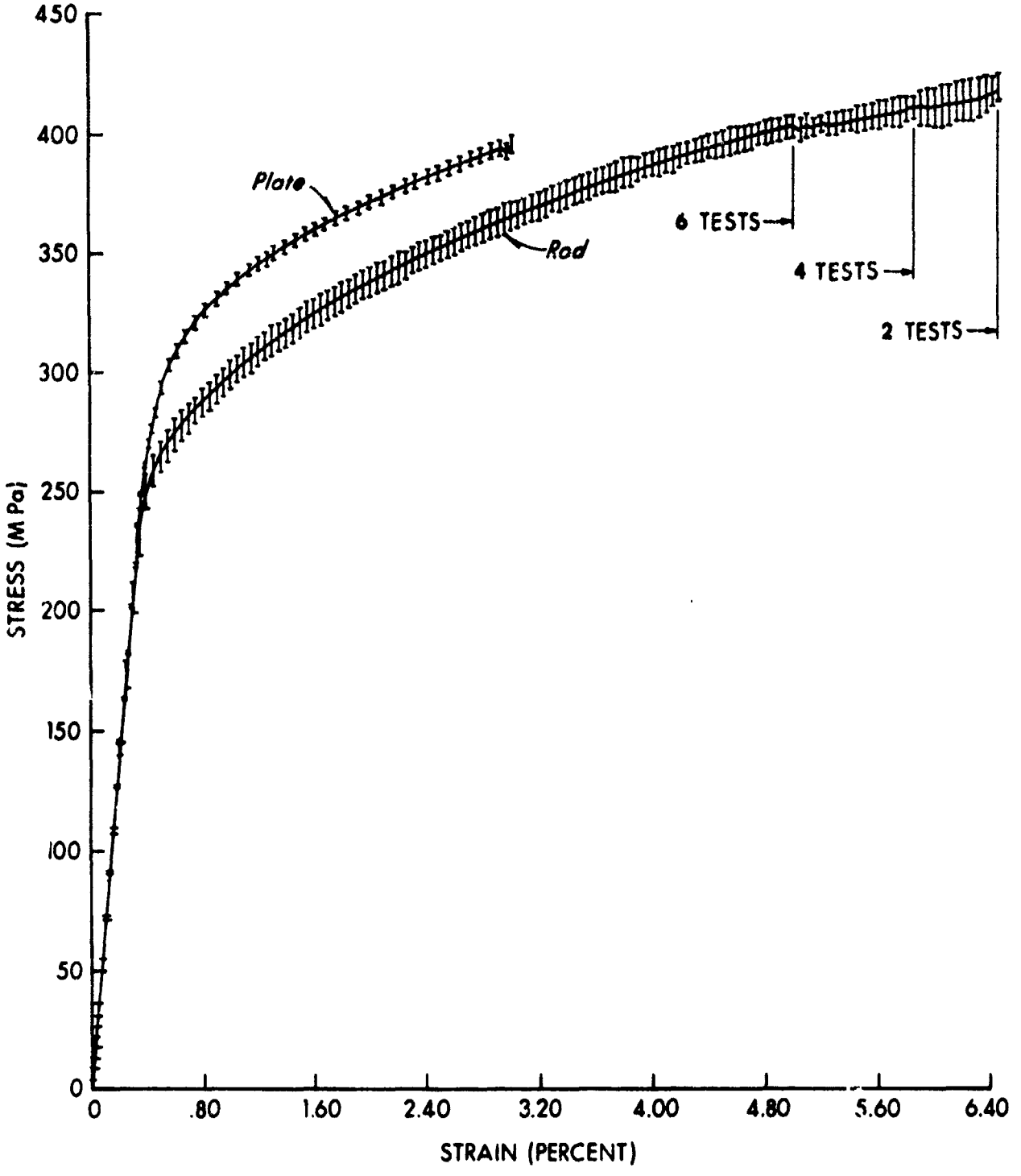

Figure 1. Average Stress-Strain Curves for Compression Tests of 5083-H131 Aluminum Rod and Plate

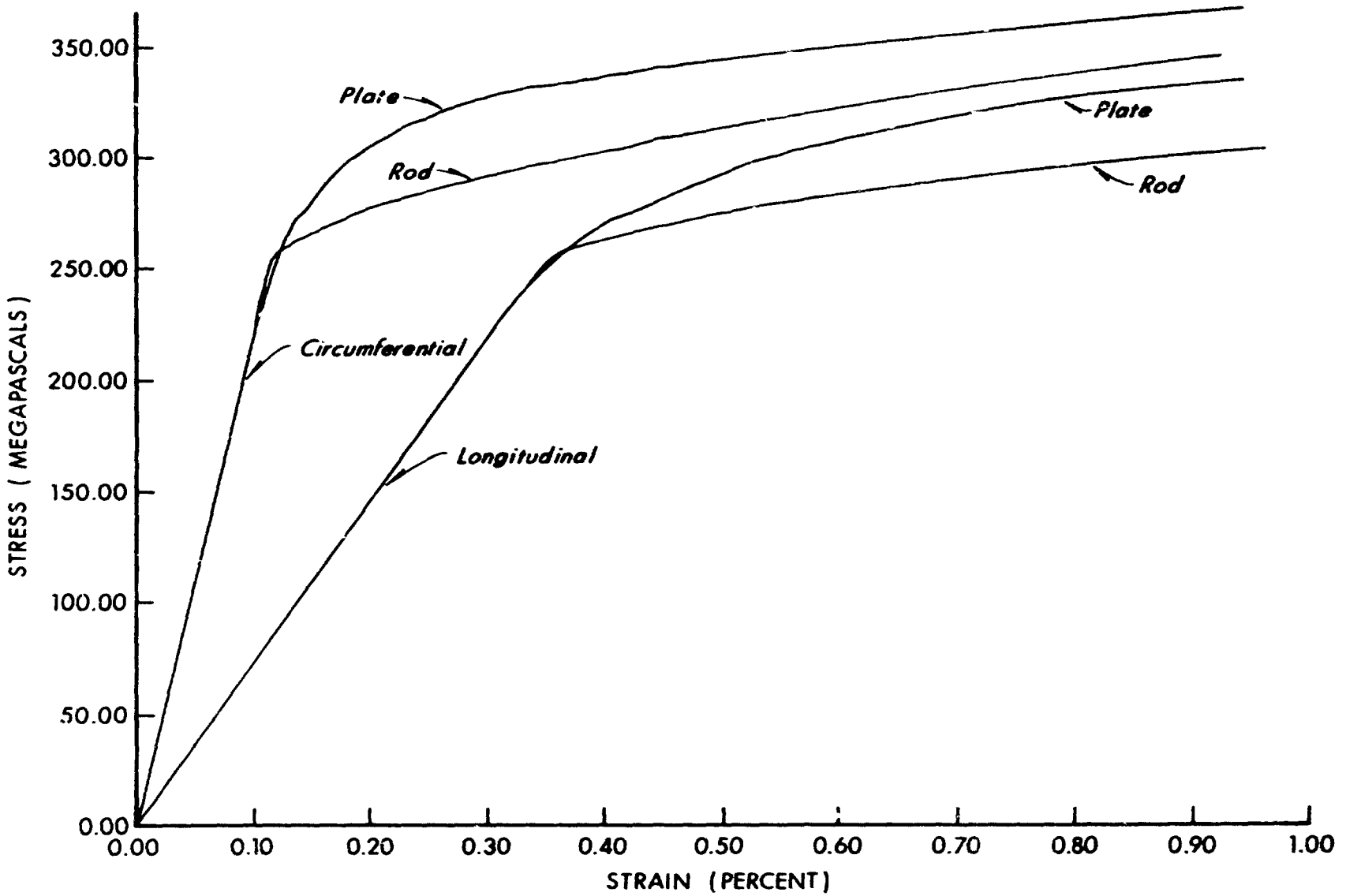

Figure 2 - Stress Strain Curves for One Specimen Each of 5083-H131 Aluminum Rod and Plate.

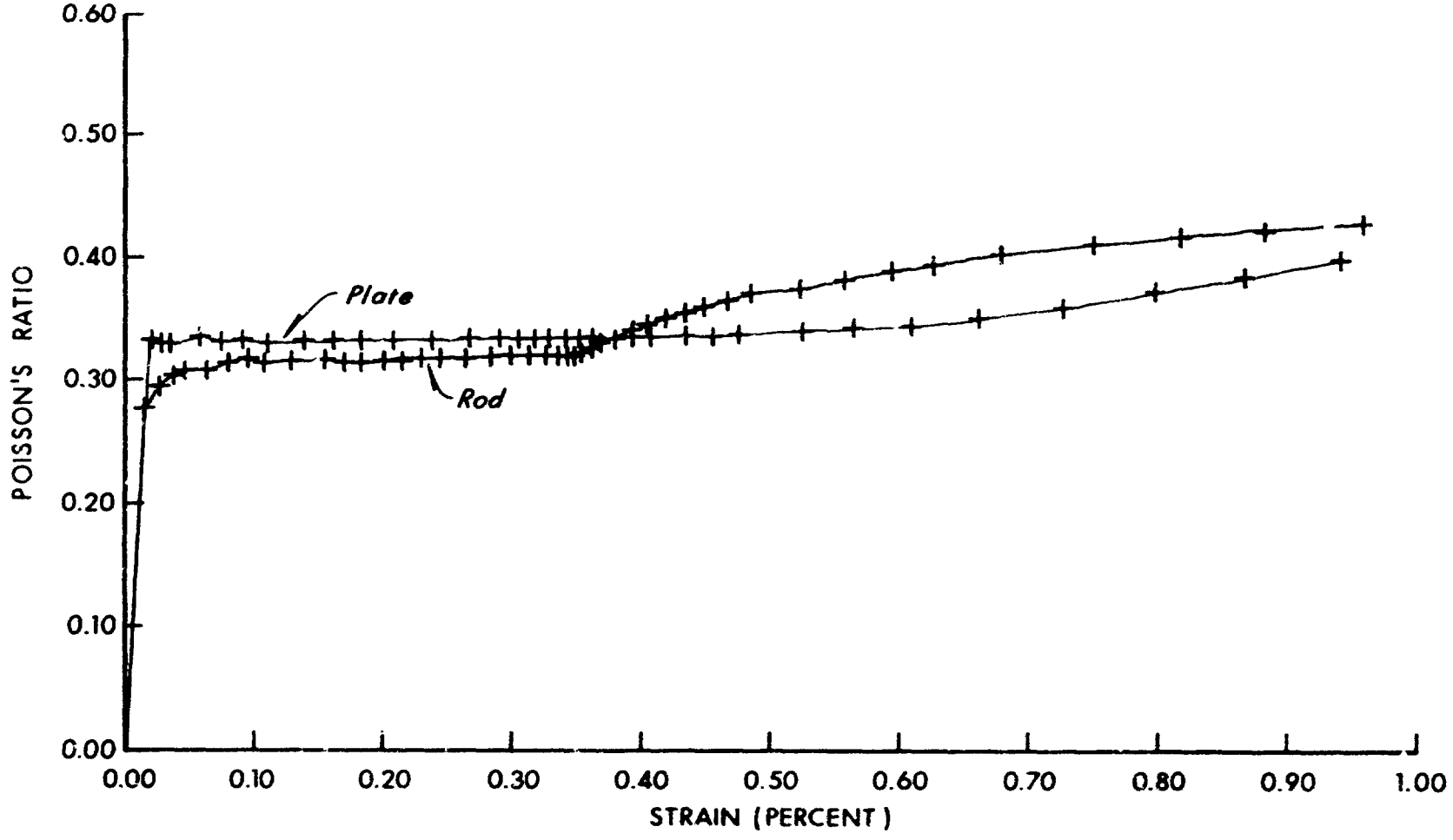

Figure 3 - Poisson's Ratio as a Function of Strain Up to a Max. Strain of One Percent for One Specimen of 5083-H131 Aluminum Rod and Plate.

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